computer-assisted radio monitoring

by Joe Cooper,
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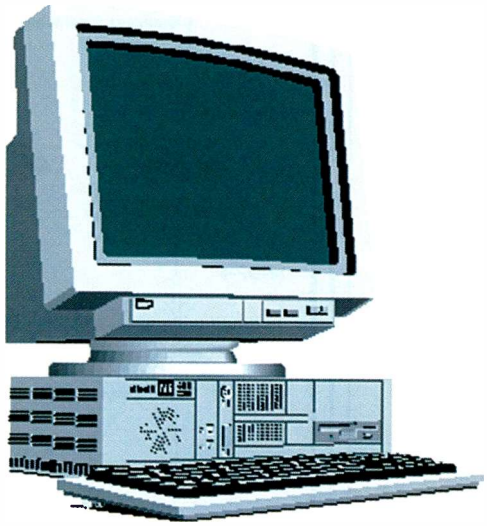
Audio Digital Recording—Part I



Next to hearing static and noise, the number one frustration experienced by radio monitors is...not being able to hear it! The next most frustrating thing is monitoring a station or signal and *missing* what was sent or said because you couldn't pick it out.

This is the reason that, next to a good antenna, the serious radio listener's best friend is the trusty tape recorder. With this device you can record a radio signal as you listen to it, or, if your radio has a timer, record a signal when you're not there to listen later.

Many hours of radio communications have been stored in this manner, capturing events ranging from the historic to the trivial. So, no matter what changes take place in radio technology over the next few years, you can bet that someone out there will still be recording off the air one way or another.

Over the next two columns I will be looking at the digital recording techniques currently available for personal computers. As you'll see, PC computer-based digital audio recording has moved far ahead of more traditional analog techniques, such as tape recorders, even in the last year. The main reason for this superiority lies in the digital techniques of signal sampling and processing.

In this month's column I'll introduce you to the basics of audio theory so you can appreciate the techniques used to make recordings. Next month I'll introduce you to the software you can use to easily make your digital recordings. Let's begin this month by looking at some important legal and ethical issues regarding the recording of audio signals off the air, then move on to an overview of the differences between analog and digital audio recording.

Audio Recording And Copyright Laws

Making audio recordings of what is coming out of your monitoring radio's speakers is governed in much the same way as radio monitoring itself; that is by democratic law, some gentlemen's agreements, and a lot of common sense.

The rule of law regarding radio monitoring states that you can listen to whatever is not specifically prohibited, such as cell phones, as long as you don't share private information you've heard with other people or use that private information for financial gain. The same holds true for recording material off the air, which is permitted as long as you abide by the rule of "Fair Use."

The term "Fair Use" is important, in part, because anything original expressed by anyone through a concrete "medium of expression" (radio, for example) is automatically copyrighted. This is true even if the sender doesn't attach a copyright notice to what is being expressed or formally register it as a copyrighted item with the government.

All the rules about copyright are laid out in simple English in the U.S. Copyright Act, 17 U.S.C. If you're thinking about making recordings off the air you should read it. You can find a copy with the help of your local public library or by going to the U.S. Copyright Office website at http://www.loc.gov/copyright/. You can download for free the entire Act or those portions of it that are relevant for you.

For those of you who want to record off-the-air signals and want to understand what the legal concept of "Fair Use" is, go directly to Chapter 1, Section 107 of the Copyright Act and read what it says. From my reading of the section (and remember, I'm not a lawyer, just a journalist), I understand that you can make audio recordings for the purpose of "criticism, comment, news reporting, teaching (including multiple copies for classroom use), scholarship, or research." Frankly, I've always seen the legal justification of the hobby of radio monitoring in these six examples.

The justification based upon "research" appears to be the strongest rational for making recordings off the air. After all, when we're using our monitoring radios aren't we researching what exists on the publicly owned radio spectrum by tuning through the various frequencies? And who's to say that what you're listening to may not one day become the subject of a newspaper or magazine item—be it an article or a radio log? That recorded material could eventually be used for a course taught by you, even if it's simply instructing a friend on how to use a radio properly. Certainly anything that is transmitted is open for comment, as long as the terms of secrecy outlined in the Radio Act are followed.

As you read through the U.S. Copyright law, you'll see there is nothing legally wrong with making off-the-air recordings of your monitoring events, as long as you respect the ownership rights of the creator of the material, as is outlined in that law. That simply means you cannot deprive the copyright owner of income by making the recording, or make a mockery of the work by "mutilation," or by significantly changing it to make it into something new, then claiming it as your own. Likewise, you obviously cannot sell what you record off the air unless you have explicit permission from the copyright holder to do so.

Also, when you record something off the air, you must leave

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it as it was originally heard to satisfy the "Fair Use" provisions of the Copyright Law. Obviously, however, you can edit your copy for length or to extract a specific item you want to save (AM radio station jingles come to mind).

I think that resolves the legal issue of making such recordings as far as this column is concerned, though I welcome comments on what I've presented here. So let's get on to the business of how to actually use your computer to record audio.

Getting Started In Audio Recording

Why would you want to use your computer to record audio signals from your radio? As I said, the trusty tape recorder has been around for years and most people have mastered the basics of using one. In fact, there are even a few popular monitoring radios out there that have tape recorders built into their cabinets.

To understand the advantages of using your computer to make audio recordings you first need understand exactly what it is you're saving when you record, no mater what method you use. You should also understand how each technique records the sound and how each affects what you hear when you play it back.

Actually, it all boils down to what sound is.

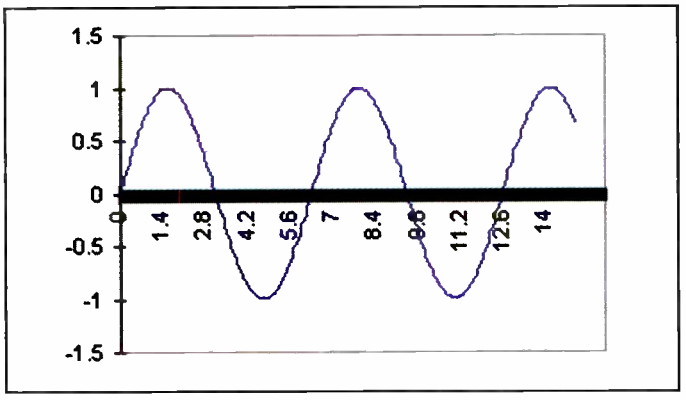

Photo A. This is a graphic representation of sound, shown as a sine wave. You have all of the components of sound, which is frequency (number of cycles per second it oscillates) and amplitude (how loud it is by the peak of the wave).

Sound 101

In its simplest form, sound is a wave of compressed air that makes our ear drums move back and forth, causing nerve impulses to flow to our brain. It is when the nerve impulses are properly interpreted by the brain, and organized into a form that our minds can understand, that they are actually heard as sound.

In graphic form, sound is generally represented as a sine wave (see Photo A). Waves have many characteristics, such as frequency, wavelength, and amplitude (which I will introduce to you in more detail as we cover this topic). While pure sound waves can be very precise looking when graphed, sound waves in the real world are made up of a multitude of different frequencies. Sound as we experience it is very complicated, containing many different frequencies of different amplitudes.

To process natural sound into electronic media, such as sound recordings or the audio output of a radio, those waves of compressed air must be converted into electrons by some means. This is generally done through a microphone or a line plugged directly into the audio output of a radio. Once this conversion takes place, the electrons produced move through electronic circuits as electrical impulses, where their characteristics are acted upon through processing or amplification. For instance, whenever you change the sound of something you're listening to on the radio by either increasing or decreasing its frequency range (treble or bass settings) you are processing the signal. Likewise, changing the volume control setting changes the level of amplification that is taking place within the radio's audio circuits.

When these electrical impulses finally encounter a loudspeaker or headphones they are converted from electrical energy back into mechanical energy. That mechanical energy moves a diaphragm (either the speaker cone or a vibrating plate in the headphones), which compresses the air near it. The compressed air then reaches our ears, hitting and vibrating our eardrums, which convert that energy into nerve impulses that our brain uses to experience and interpret as sound.

Without getting into too much theory (I've probably used too much for some people already) our brains seem to prefer clear signals, because we find so much information in sound. When somebody speaks we are able to make sense of what they are saying, and when people play music, we are able to pick out notes. But to do this, the sound must be loud enough and clear enough for us to understand. When you add a lot of extraneous sounds to what you're listening to, your brain starts to have problems processing the information. These additional sounds are heard as noise. The more noise there is, the greater difficulty the brain has in finding the particular information it is trying to understand.

Analog Recording With Tape

This brings us back to our tape recorder. If there's one thing it does very well, it is to record everything it "hears." This results in what is known as an "analog" signal, which is simply a signal that includes absolutely everything that can be picked up by the recording device.

If the signal being "heard" by the tape recorder is very good, the signal is said to have a lot of fidelity (ranging from "high" to "low"). This term simply means that the noise is (subjectively) hardly heard when listening to the sound played back, while the information (voice, music or natural sound) is (again subjectively) very strong and clear.

The problem with using an analog tape recorder is in controlling the level of noise that's recorded along with the information you want to hear. The success in doing this can be expressed as either fidelity (a subjective measurement) or signal-to-noise (S/N) ratio, which can be objectively measured with audio test equipment.

When you make tapes of sound in a controlled environment, such as a professional audio studio, you can achieve very high fidelity in your recording. However, when making tape recordings in the real world, particularly when the signal is coming from the noisy world of radio waves, it's much harder to achieve the same level of fidelity. Typically, when you use a tape recorder you wind up with a low signal-to-noise recording. While there are techniques that can "dig" a signal out of the noise, generally they're very expensive and the results are not all that great.

There's also the issue of the noise that's a natural component of the tape you are using to record with. (Just play a brand new tape and listen to the hiss). This is where digital recording comes in. While not as convenient as using audio tapes, digital record-

ing media produce excellent signal-to-noise ratios with great fidelity which more than makes up for the extra effort involved.

Digital Recording Basics

First, what's the difference between digital and analog recordings? Let's say you've placed a music CD into your computer's CD player. When you play it, it produces a signal in the computer as it would in any electronic device. However, rather than being the complex sine wave of an analog device (such as, an old-style LP or 45 record player), the signal is represented by a series of zeros (0) and ones (1). Rather than the sine wave that you would find in an analog electronic device, the computer moves the data through its circuits as electronic pulses, which are represented as zeroes or ones. The computer is merely representing the sine wave as those numbers.

This method of representing analog sound as numbers is called "sampling.". The most important thing to remember when comparing a digital signal to an analog one is that analog recordings pick up everything, including noise, while digital recordings only record small samples of what you hear, but with less noise (see Photo B).

With analog recordings all you are concerned about is controlling the level of sound (volume) and the fidelity (treble and bass), but with digital you have that plus the rate at which you're sampling the sound. As I'll be showing you, the greater the sampling rate, the closer the digital recording will be to the original source. The problem with this is that the more samples you

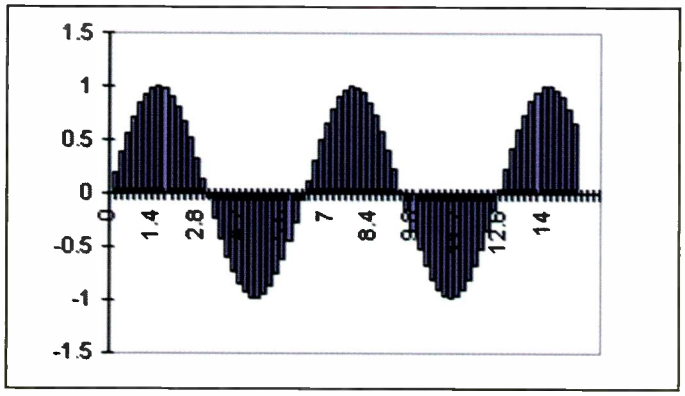

Photo B. This picture shows you how a sound wave is sampled into a digital representation. See how each part of the sine wave is sliced up into a small part. The computer takes these samples and stores them as zeros and ones. When it is played back through the sound card, the sampled bits are used to reconstruct the sound wave. The more samples you have, the more accurate your reproduction of the original sound.

make, the more data you place into your computer. As a result, a highly sampled sound will be a larger file than a less well-sampled sound. The trick is to work out which sample rate is best for you, given your particular recording requirements.

Fortunately for radio monitoring purposes, the amount of sampling required to achieve excellent results is not as great as that needed for digitally recording a symphony orchestra. So you'll be able to save your audio recordings in files of reasonable size.

There are also a number of ways of dealing with the size of an audio file without changing the sample rate. This is done through the use of various data compression techniques, which I will cover in more detail in next month's column.

Next Month

Next month I'll outline the actual techniques used to record digital sounds with your personal computer. I'll show you how to properly set up sampling rates and other key settings using several digital recording software packages appropriate for radio monitoring, including some already available in your Windows operating systems.

Feel free to write to me with ideas, comments, and suggestions. My mailing address is "Computer-Assisted Radio Monitoring," C/O Joe Cooper, PMB 121, 1623 Military Rd., Niagara Falls, NY 14304-1745.

You can also e-mail me at my new address, carm_popcomm@hotmail.com. But please don't use the old one at joe@provcomm.net, because it is becoming unusable due to the amount of spam I receive each day (well over 100 junk e-mails). I'm finding that because of this spam I am missing important e-mails from my readers. The hotmail account offers some protection from that and it's a dedicated e-mail address for the column that makes it easy for me to sort through. Thanks in advance for your cooperation.

Don't forget that I can't answer general questions about computers, software, or operating systems, but I will do my best on any questions about the content of the columns or computer-assisted radio.

Thanks again and I hope that the information provided here helps you get more out of your computer and radio monitoring than you ever thought possible. ■

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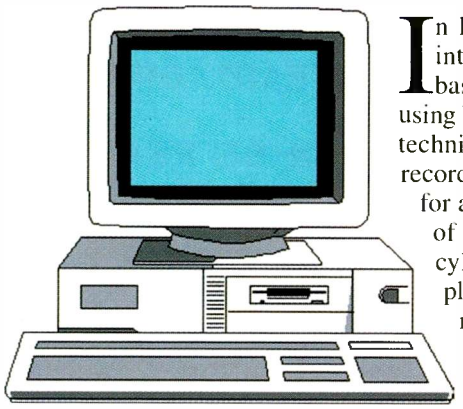
Audio Digital Recording Column—Part II



In last month's column I introduced you to the basics of audio recording using both analog and digital techniques. While analog recording has been with us for a long time now (think of Thomas Edison's cylinder recordings, long playing records, and tape recorders), many people today are now switching over to digital recording.

Digital's growing popularity is largely due to the greater control you can have over how you record and the greater dynamic range of sound when you play it back. Also, digital recordings don't degrade as quickly as analog recordings. Remember when records and audiotapes used to "wear out" with use? Both would start to get hiss, crackles, and pop over time. In fact, a lot of audio engineers' time and effort when into developing special technology to prevent that degradation from happening.

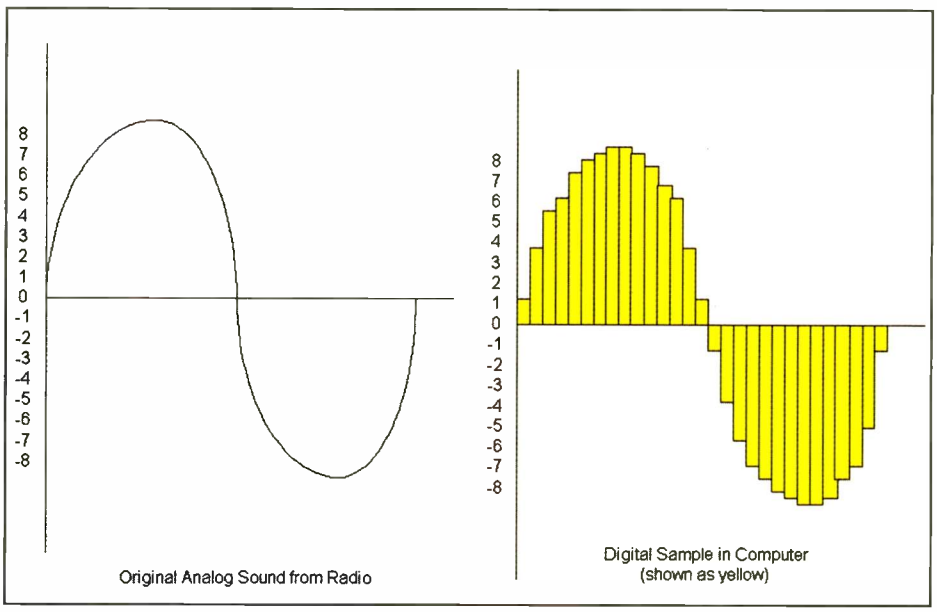
Remember how top-end record players used special balanced weights to make the weight of the arm and needle as light as possible when touching the groves of an LP? Or how audiotapes came in various makes of recording material in an attempt to keep background hiss to a minimum, which was then reduced even further through the use of special audio filters? That's not the case with digital recordings. Now you have the potential for an extremely long lifetime for a digital recording, which will sound exactly the same as the first time it was played, no matter how many times it is listened to.

These characteristics (precise recording control, good output sound and longevity) make digital audio particularly popular among people who record signals off the air for radio monitoring purposes. Digital is the perfect medium radio monitors who want to not only record, but also preserve what they monitor so it can be enjoyed many years in a form that's as close as possible to the original sound that came out of the radio's speakers.

Yet there is more to digital recording than simply good quality reproduction. In most cases, the signals being monitored aren't broadcast quality; they can be distant, full of interference, or otherwise difficult to hear. What digital recording techniques offer is a means of not only capturing the signal, but also of making it easier to listen to by improving the signal-to-noise ratio of the recording.

This means that you hear more signal than background noise and static because the recording technique doesn't add any extra noise, which is generally the case with analog recordings. This removal of extra noise when recording can be further enhanced with other digital filtering techniques, such as Digital Signal Processing (DSP) and digital band-pass filtering (removal of a range of frequencies above and below the center frequency through software programming).

This month I'm going to look at some of the basic digital recording techniques available to you through your home computer. Remember that to make such recordings, you'll need a working digital sound card installed on your computer. You'll also need a means of hooking up your radio's sound output to either your microphone or line-in inputs on that sound card. Lastly, you'll need audio speakers to hear the results.



An analog sound wave is made up of two basic components: frequency and volume. You see that with the sine wave on the left. On the right is a representation of how your computer samples that sound wave. Rather than volume, the dynamic range of the sound is represented by bit-depth (in this case 8 bits), and the frequency is sampled several times a second (represented by the yellow bars). Those yellow bars would actually be a series of binary number (zeros and ones) in your computer. When you play back the digital recording, information contained in the binary data would be used to re-create an approximate representation of the original analog sound wave. In general, the greater the bit depth and sample rate you use to record the original sound, the more accurate the reproduction will be when you play it. However, there are limits to amount of bit depth and sample rate that you can use, which are explained in the column.

Getting Started In Digital Recording

There's more to digital recording than simply plugging your radio's audio output into your computers audio input, recording the signal to your hard drive with a digital recorder, then listening to the results. Frankly, if you do that without some background knowledge of digital recording, what you eventually hear may disappoint you because what you're listening to coming out of your radio's speaker (or headphones) is *analog sound* which contains every part of the signal, including noise.

While it may not be music to some people's ears, the fact is that such sound has many different frequencies and harmonics, which your ear and brain can use to make sense of what you are hearing. However, when you use your computer to record it, the result is a *sampled* source of sound, so parts of it are actually missing. Therefore, when you play back digital recordings, what you're listening to is not the original sound you heard, but an approximate representation of it. Depending on how sensitive your ears are, your hearing may be able to discern the fact that there are missing sounds.

For some people this isn't a problem, in fact, it can be a very powerful tool in overcoming some of the difficulties encountered with radio monitoring. Consider how much better a radio signal could be if you could remove background noises. That is what digital recording can help you do, and much more.

But before you make a digital recording, you must first make a decision as to how closely you want the final result to represent want you originally heard coming out of your radio. There are two reasons for this. First, the quality of sound you create will depend upon the type of digital recording technique you use. There are several techniques available, each producing its own level of audio fidelity (that is the quality of reproduction that is achieved). Second, in general, the higher the quality of the digital sound recording you make, the larger the resulting file. As a rule of thumb, the best recordings result in very large computer files because they have the most digital information. As I'll show you, however, there are new digital recording techniques that can compress large computer files into smaller ones with out noticeably reducing quality.

In this and future columns I'll discuss the various types of popular audio files that you can create, specifically WAV, MP3, and WMA. As you'll see, each file type produces a particular audio quality, which can range from hi-fidelity sound (as produced by a top quality CD) to what you would hear coming from a cheap AM radio.

First, let's look at why there's such a wide range of audio outputs in digital recording so you can choose the best output method for your particular radio-monitoring situation. This knowledge will also help you properly set up and control the digital recording software you are going to be using.

Digital Audio Quality

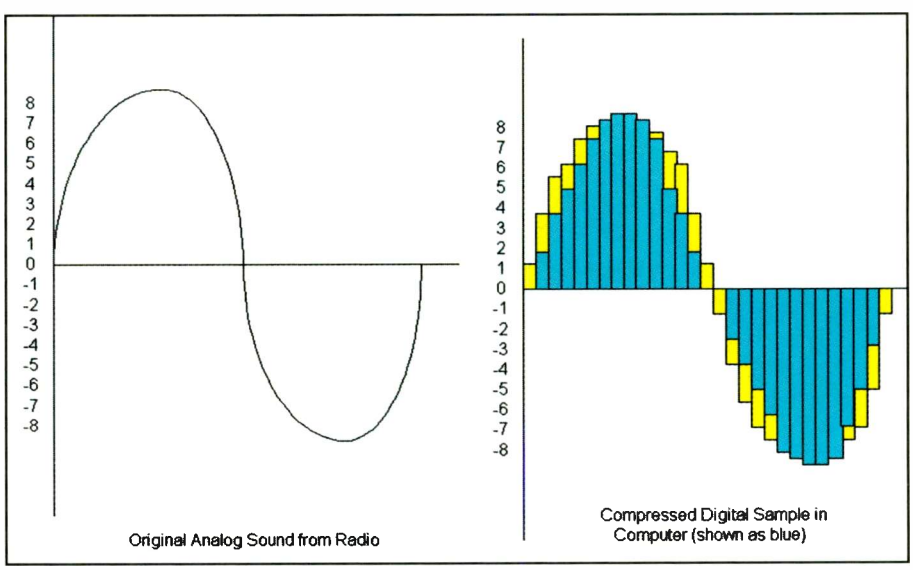
You create a digital audio file through "sampling" an analog signal by using computer hardware and software that converts each sample into a sequence of digital numbers (zeros and ones to be precise).

There are two important components to this sampling: the sample rate (the number of times that a sample takes place over a fixed period) and the bit depth (the amount of information that's captured in each sample). With some digital recording software you can control the sample rate and the bit depth, so it is important to understand what these components are and how they are used.

The sample rate determines the highest frequency that can be captured from the analog signal. As a rule of thumb, the highest frequency that can be preserved when making a digital recording from an analog source is always less than half the sampling rate. So, for instance, the 44.1-kHz sample rate used by CD audio can capture frequencies up to about 20 kHz. If you sampled at 32 kHz, the upper audio range is reduced to roughly 16 kHz. If you went all the way down to 4 kHz, the upper audio range would be about 2 kHz.

You can actually increase the sample rate with some digital recording software, but frankly it is unlikely that anyone, except maybe your dog or cat, is going to hear the results. Likewise, if you're recording something with an audio dynamic range much less than 20 kHz (for example, SSB, RTTY, or CW signals), you gain nothing but noise and static in your recording by using a high sample rate—not to mention large computer files of your results.

The digital audio bit depth used in digital recording determines how many different levels of volume you can capture from the original analog signal. Here the


8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8
Original Analog Sound from Radio
8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8
Compressed Digital Sample in Computer (shown as blue)

This picture illustrates the difference between an uncompressed and compressed digital recording. The blue bars show the compression, which has eliminated some frequencies (the upper and lower), while leaving the middle frequencies alone. Other frequencies that are not important have been reduced or eliminated as well. When the human ear hears the results of this compression the missing parts will not be missed, as they are not normally heard anyway. In this method of compression, the removed information reduces the amount of information stored, making the file smaller. This is a simplification of the actual methods used in most audio compression, which use many different ways to mask, eliminate, or reduce the information stored in a digital file in order to reduce it to its maximum amount without losing noticeable sound quality.

greater the number of bits, the greater the dynamic range that can be captured by the digital version of the analog signal. The standard today is to record with 16 bits. This means that each time an analog audio source is sampled, it can be divided into 65,536 levels (2 to power 16), which translates to a dynamic range of 96dB. In other words, 16 bits can capture a wide range of sound, from almost pure silence to 96 dB. What that means is that you can hear extremely minute differences in sound between signals. Thus, a 16-bit depth will let isolate one signal from another with greater ease by enabling you to distinguish subtle differences in volume.

This is where digital really begins to outshine analog, which cannot offer the same dynamic range, at least not without going to a very expensive radio. The only problem you face with good digital recordings that sample at 44.1 kHz and 16-bit depth is their resulting size. For example, a three-minute recording at that rate and depth can result in a 30-megabyte file.

Some of you may have the storage capacity to manage such digital audio recordings, and you may wish to make them because of the better quality. However, not everyone wants or needs that level of recording quality, especially if you are monitoring radio signals that aren't high fidelity to begin with.

So let's take a look at each audio file type, with an example software program that you can use to make a recording with.

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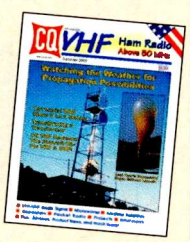

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WAV files

WAV (pronounced wave) files are complete and uncompressed digital samples of a sound source. They're generally a high-quality format for storing music or sound, but are very large because of the amount of information needed. For instance, a stereo (two-track) 44.1-kHz sample (44,100 slices per second) with 16-bit technology (65536 levels) requires 176 kilobytes of information per second. This is why early digital sampling musical instruments could only sample for a few seconds—they simply didn't have the memory storage capabilities. Nowadays, however, it's possible to store large wave files onto hard disk or CD. A 74-minute wave file takes up 650 MB of storage space and 80 minutes can be stored on 700MB CD media.

MP3 Files

This is a fairly new method of digital recording that has gained a lot of popularity recently. Its main characteristic is that it produces very high-quality sound while creating a computer file that is only 1/12 the size of a WAV file. This is possible because, rather than trying to capture everything contained in the sound, MP3 only records the information the human ear can actually hear. So when you record with MP3 you get a very good approximation of the sampled sound. It's so good, in fact, that when the sound enters your ear and is processed by your brain, you think you're listening to something very close to the original.

So with MP3s you get very nice sound quality and very small files (rather than recording a maximum of 80 minutes of sound on a conventional CD, you can now store 12 times as much, or roughly 960 minutes). One problem for some people, however, is that MP3s require a very powerful computer CPU to produce the best sound. The reason for this lies in the complex method it uses to encode and decode sound.

When using MP3 to either record or play on a computer without a fast processor, some people find they are limited to the number of programs they can run simultaneously. Thus, using an MP3 recorder (or player) while using a software program to control a radio or run a log program may cause the computer to run very slowly, or even lock up completely.

There are other considerations as well that will be discussed after looking at the next digital recording file type.

WMA

WMA or Microsoft Windows Media Audio is beginning to replace MP3 in some cases. It is a well-designed audio recording method that can handle all types of audio content. You can choose from a range of speech-only audio, recorded with a sampling rate of 8 kHz, to 48 kHz higher than CD quality stereo music. WMA is also very resistant to degradation due to loss of data while recording because it does not use temporary memory, as MP3 does, to deal with a wide range of frequencies.

Most important for many who choose this standard is that it does not need a powerful CPU to record or play back. This allows you to run multiple software programs while running WMA software. Also, the compression method used to create audio files requires much less disk space for storage than MP3. Finally, WMA provides much clearer sound with greater tonal distinction than other recording methods using compression.

Put plainly, WMA offers a combination of good sampling rate with good bit depth to produce better-sounding content across all supported bandwidths. It also provides both high-quality mono and stereo audio, and so is a very good choice for radio monitoring.

There Is No Free Lunch

At this point you have to start asking some serious questions about what your recording priorities are going to be. In recording using compression techniques, as with everything, you don't get something for nothing. No, I'm not talking about bootlegging music by copying it off the air, but rather what you gain or lose by using a compression technique to record a radio signal.

For instance, MP3 works by removing parts of the sound that you hear, but that may be critical for you when you are trying to identify a weak or distorted signal. If you're listening to a shortwave broadcaster with a strong signal, or strong local signal on your scanner, then MP3 may be what you are looking for. On the other hand, if you're trying to use digital recording to pick out a very weak signal with lots of background noise, then you're

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going to want as much data as possible, so WAV may be your best bet, with WMA being a close second.

This leads us to the real point of digital recording for radio monitoring: it's a whole new field to experiment with. Nobody has the ultimate scoop on what is the best method. Frankly what I've been describing here are the most popular non-professional methods of digital recording and that are the easiest for most people to use. It is a good starting point as we continue to explore computer-assisted technology in the space of this column.

In this regard your feedback on the use of these different modes—both positive and negative—is really important. What do you find works best for your type of radio monitoring? The only way to find out is by doing what radio hobbyists have done since the days of crystal radio sets and earlier: experiment, experiment, and experiment some more. Then share your results with others, which you are welcome do through this column.

Next Month

Next month I'm going to—finally—introduce you to some digital audio recording software and give some pointers on some audio playback software as well, specifically software for those who want to record what they hear on their monitoring radios. I'll be looking at those software digital recorders that are easy to use and have the capability of starting and stopping recording at specific times.

Even if you don't have a monitoring radio that can be directly controlled by a personal computer (e.g., many of the popular portable types), these modern digital radios have built-in programming capabilities. This means you can set up your radio to tune into a specific time and frequency, and have your digital software turn on and record at the same time. This way, if you're at work or asleep at night, you can still capture the signal you want (depending upon atmospheric conditions and other factors). Of course, you'll need to connect your radio's audio output to the audio input of the computer's sound card (line-in or microphone) to create the actual recording.

Please e-mail or write to me with ideas, comments, and suggestions. Please note that I have a new e-mail for the column, carm_popcomm@hotmail.com. Don't use joe@provcomm.net because it's becoming unusable due to the amount of spam I receive each day (well over 100 junk e-mails). The hotmail account offers some protection from that and is a dedicated e-mail address for the column that makes it easy for me to sort through.

I also first announced that the hotmail address would be carm_popcom@hotmail.com. I'll be using that one for a short while, but in about a month from this publication I'm shutting it down. So please use the one listed above (with the two "m"s. Thanks in advance for your cooperation.

You can still send me regular mail (and many of you are) at my mailing address: "Computer-Assisted Radio Monitoring," C/O Joe Cooper, PMB 121, 1623 Military Rd., Niagara Falls NY 14304-1745.

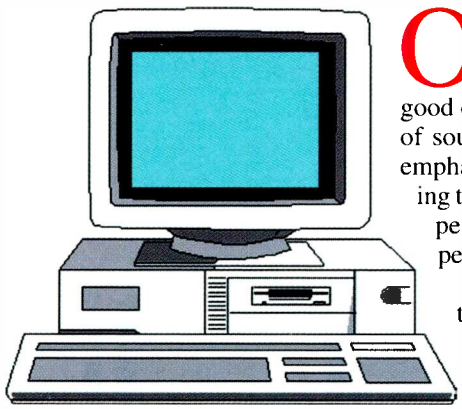
Remember, I can't answer general questions about computers, software, or operating systems, but I'll do my best on questions about the content of the columns or computer-assisted radio in general.

Thanks again and I hope that the information provided here will help you get the most out of your computer and monitoring radio than you ever thought possible ■

computer-assisted radio monitoring

by Joe Cooper, joe@provcomm.net

Digital Audio Recording—Part III



Over the last two columns I have tried to provide you with a good overview of the theory of sound recording with an emphasis on digital recording techniques that you can perform using a basic personal computer.

This month I'm going to show you how to put that theory into practice by using the digital recording software called "Sound Recorder," which is provided as an accessory with most versions of Microsoft Windows.

While at first glance the Sound Recorder software may appear to be simple, it actually has several well-designed features that make it a very useful digital sound recording tool. The software also contains a number of features to help beginners learn how to use digital recording for radio monitoring.

After you've learned the basics of actually recording the audio output from your monitoring radio, you can then go on to splice and edit those recordings using the same software. You can also add in audio tracks, so you could, for example, add in your own recorded comments about time, date, frequency, and the content of the recording.

In future columns I'll introduce you to commercial digital recording software packages that have more features, but are surprisingly inexpensive to buy. However, there is no point in moving up to a more complicated application until you first master the basics.

So let's put a little time in now and lay a solid foundation that will serve you very well in the future.

A Quick Review

For those who may be just picking up on this series of columns, or who need a bit of a refresher, I just want to touch upon a few key points about digital recording.

What you should understand by now after having read the two earlier columns is that sound and sound recording can be a complex topic if you go into it in detail. However, when you get right down to it there are only a few simple points you must know in order to understand exactly what you're doing when making any kind of recording.

The first rule about making an audio recording is that no matter what type of recording it is, there will always be some compromises when you play it back. This is because nothing can fully match the dynamic range of your own ear hearing natural sounds.

As I pointed out, there are two primary types of audio recordings: analog and digital.

Analog recordings make a record of practically everything that is "heard" at the recording source. Unfortunately, this also includes background noise from the recording process itself. While such recordings are said to be very high fidelity (that is how much of the original sound is accurately captured), this is only achieved through the use of top quality recording technology and material (vinyl disks or recording tape).

On the other hand, digital recordings do not record everything that is "heard," but rather only make small samples. These samples are made at a very high rate (several thousand times per second) so that when they are played back they give the illusion of a continuous recording.

What you gain by using digital recording is a very large dynamic range of sound, so that there appears to be virtually no noise created by the recording technique itself. This can be very important if you are recording off the air, where you can be fighting with fading (QSB), static (QRN), and man-made noise (QRM).

So the promise of digital recording is that you should be able to capture fainter signals with greater accuracy than with an analog recording. This is because you're not adding any extra noise when you make the recording.

Likewise, no mater how many times you play back a digital recording, you will not hear a degeneration in the quality of the sound, so that what you record today will still sound exactly the same many years from now, no matter how many times you have listened to it.

So now that we've established what digital recording is and why it's superior to analog, let's look at how it is done.

Audio Hookup Basics

Before getting into digital recording using the Sound Recorder software, you must first get the radio's audio signal into your computer's sound card. (See **Photo A**.)

First off, just to clear up any confusion, you do not have to have a computer-controlled radio or special radio in order to make digital sound recordings (some readers have expressed some confusion about that). You can actually make digital recordings from any make or model of radio.

The "hard" way of making a digital recording is to place a computer-compatible microphone that is hooked up to your computer's sound card close to the radio's speaker. While you can do it this way the problem is that the type of microphones that are used with computers are not designed to produce "hi-fi" sounds, as they were originally intended for voice recording only. Microphones can also pick up extraneous sounds that can take place in the room where the recording is being made (people talking, chairs pulled across floors, children or pets, traffic sound, etc.).

What you really need to do is set up a direct hookup between the radio's audio output and the "Line Input" of the computer's sound card (sometimes called "Line In" for short. The Line Input

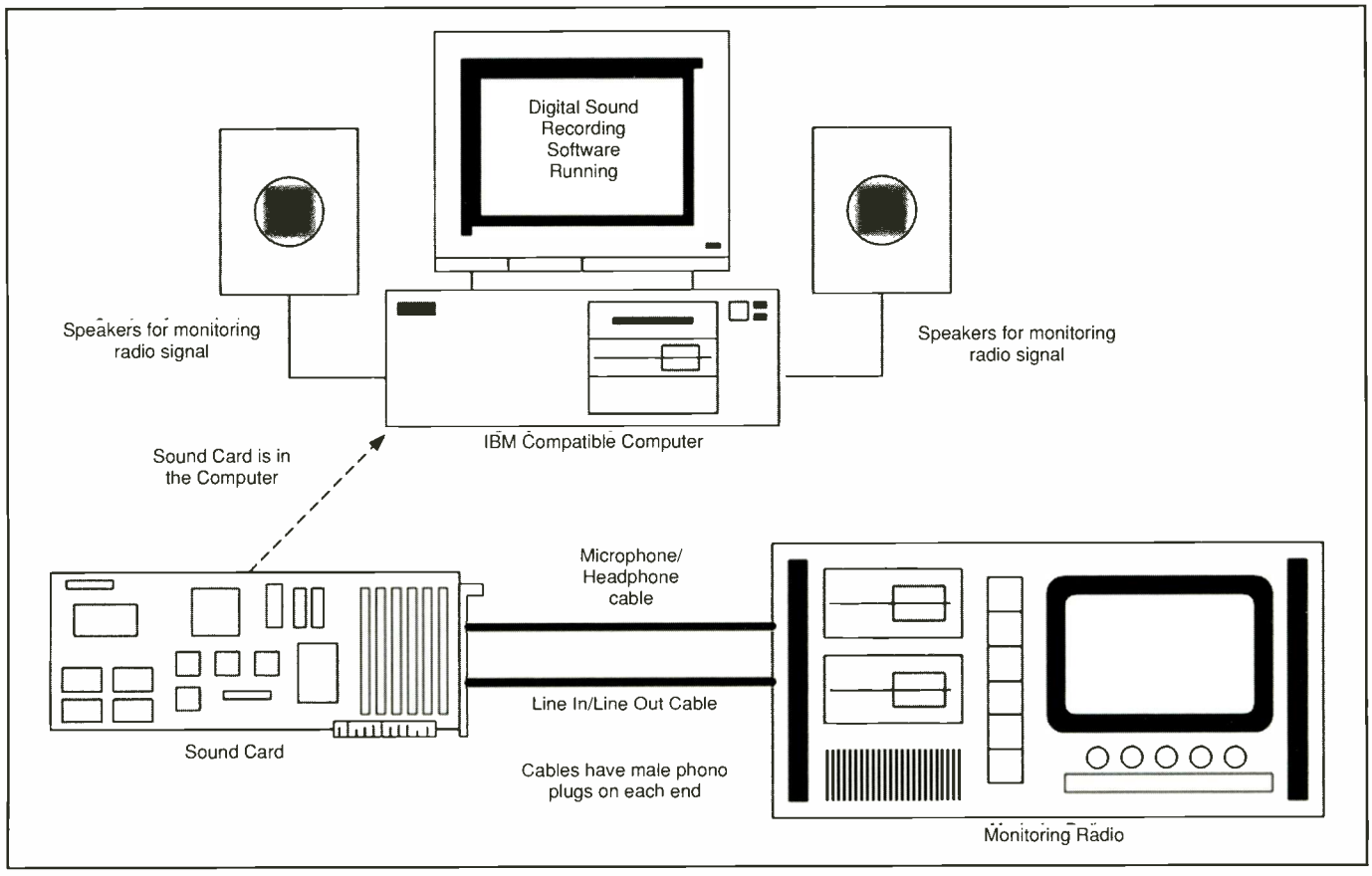


Photo A. The basic setup for digital recording from your monitoring radio. As the column explains, you don't need two cables, unless you want to listen to the radio's audio signal through your computer's sound card and speakers.

is generally clearly marked (either by name or with a color code) and you connect to it using a 1/8-inch male stereo plug. It is designed specifically for audio recording and nothing else.

You can hook the radio up to it in several ways. The absolute best way is to have a radio that has a "Line Output" jack (sometimes called "Line Out" for short). This ensures that the most compatible signal (about 200 millivolts) is delivered to the Line Input socket. What you will end up with is the best possible audio signal for making a digital recording.

If your radio does not have a Line Out jack, the next best thing is to take the signal off a headphone jack, if one is available. If your radio has a standard 1/8-inch headphone jack, you can generally buy a simple cable with two male phono plugs to connect between the radio and the Line In of your computer's sound card.

One thing you should keep in mind when buying this cable is that while your radio may be mono (a single sound channel), the socket you plug into may be stereo plug compatible. You will still only get mono sound if you plug in a stereo headphone, but radio manufacturers do this to save a bit of money (mono components are harder to find now) and to make it simpler for you because it's easier for you to buy stereo cables and headphones.

The bottom line: read your radio's operator manual carefully to find out what type of cable or headphones you need. It should be clear, but if not, contact the manufacturer or your dealer.

Before you buy the audio cable, make certain it's long enough to reach the computer properly (voice of experience here), so take a moment to actually measure the distance between the radio and the computer. Likewise, if your radio's audio output is non-standard (an older style phono-plug for example) you may have to build a custom cable or have one made for you.

If your radio has both a headphone jack and a Line Output jack you can also use two cables to connect up to your computer's microphone and Line Input at that same time. This setup allows you to record the sound via the Line In/Out while monitoring the sound through your computer's speakers.

The absolutely worst case is when you're using a radio that has no speaker jack. In that case you may want to try building a custom cable and solder the output leads to speaker. However, never connect such a cable directly to your computer's sound card. If you do, you may end up sending unexpected high voltages or currents into the computer, damaging or even ruining it.

To transfer an audio signal directly from your speaker via a cable you ***must*** use a proper audio isolation transformer. This electrically isolates the computer from the radio, while safely passing the audio signal.

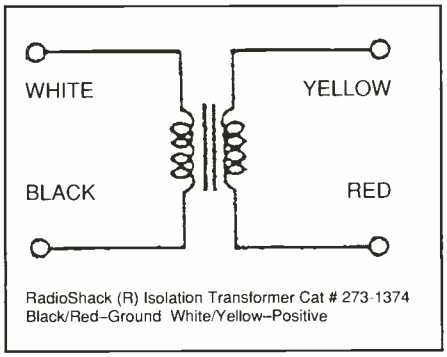


Photo B. This is the schematic for the isolation transformer you use to keep unwanted voltages and currents out of your computer.

Photo B shows a diagram of such a device, along with the RadioShack part number of the item (it's inexpensive). If you have basic soldering skills you can put together your own cable.

Once you have your radio's audio output connected to your sound card and everything is turned on, it's time to start making some digital recordings.

Before You Make A Digital Recording

If you have been following my column for a while you know that I'm an advocate of pre-planning, keeping a notebook, and working with checklists when undertaking any computer/electrics project, no mater how small. Undertaking a computer project by any other method is just hacking around and is a good formula for frustration and failure.

So let's start with the most basic question, "Why are you making a digital recording of your radio monitoring session"? As with anything else, the answer to that question will determine how you are going to set up your digital recording hardware and software.

Consider the following digital recording scenarios. Let's say you're...

...a ham radio operator who participates in contests. You want to have an audio record of all of the contacts you make as a backup to your official log.

...a shortwave broadcast listener who wants to record a favorite program.

...a UTE radio monitor who wants keep a record of a session where multiple frequencies are scanned for activity so you can go back over the recording and capture details for logging.

...a Broadcast Band DXer or listener who wants to record radio callsign jingles for posterity, as well as local programming and commercials.

...a person who wants to record VHF/UHF public service communications during a local emergency or disaster so you have an historic record of that event.

These are only a few of many possible examples, and I'm certain you can come up with many more (how about writing in with some of your own?). The key point here is to plan out how you are going to be successful.

First, let's just look at the task at hand—actually making the digital recording.

Making A Digital Recording

As I mentioned at the beginning of the column, I'm going to introduce you to a simple but useful digital recorder. If you take time to get to know it well and make it work properly, you will have the foundation knowledge and skill to master more complicated audio recording software programs that I'll introduce in future columns.

If you're using just about any version of Microsoft Windows designed for a desktop or laptop computer, a digital audio recorder called "Sound Recorder" is included with the software utilities.

If you click on the "Start" button in the lower left corner of your desktop, then go to Programs->Accessories->Entertainment, you will see the program called "Sound Recorder" (it's identified by a little yellow audio speaker). Click on it once to open it. It should appear as shown in **Photo C**.

The Sound Recorder program is very simple to use, but there are a few things you should keep in mind. The majority of problems that can occur in audio recording, that are not related to hardware, can generally be traced to an improperly set up software volume control.

Photo C. The user interface for the Sound Recorder software utility that is provided in most versions of Microsoft Windows. It's deceptively simple when you first look at it, but actually has many important features. The circle control begins recording, the square stops it and the triangle is the playback. The green line is the "Oscilloscope" when there is no signal.

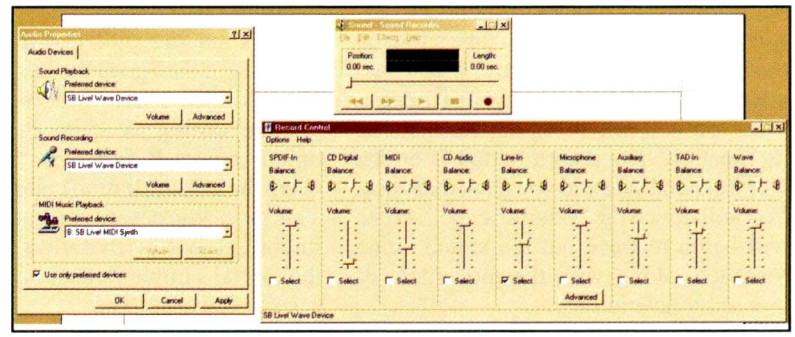


Photo D. Here you see the audio device controls and the volume control. You can use the pull down menus to select from various sound cards (if you have them installed in your computer) or devices. You select the volume control you wish to use by clicking on the select box and moving the slider to the desired position.

To see this volume control go to the pull-down menu item called "Edit" and click on it once. When the menu opens up, go to the item called "Audio Properties" and click on that once. You will then see a new window open as shown in **Photo D**. This new window is very important as it allows you to select the sound card you're going to be using and control the input and output volume of that device.

You can also use the controls in this window to troubleshoot problems. As mentioned, it's been my experience that most audio recording problems can be traced back to an improperly set up output volume control, where it has been accidentally set to "Mute" or too low of a volume. Another common problem is the input volume control, where the proper input has not been selected.

Photo E. A glimpse of the Sound Recorder software in operation recording sound off the air. Note that the "Oscilloscope" is showing the volume level of the sound being recorded. The length of time that the recording has been made is shown, as well as the "position" of the slider. The slider can be used for editing the sound recording later on. You stop the recording by clicking on the square, and then saving the file by clicking on the "File" pull down menu and giving the sound recording a file name.

If you take a look at **Photo E** you will see that you have separate volume controls for the microphone input and Line In input. Make certain that the proper one has been selected and that the volume control is set to the correct level. Take some time to learn these controls in detail and experiment with the settings to see the affect changes have upon them. Jot down in your notebook which settings work best for you.

Once you're certain you've connected your radio to the computer it's time to try making a digital recording. Turn on the radio, tune in a station that produces a fairly constant signal, and then take a look at the Sound Recorder software. If you pass your mouse pointer above each of the controls you will see a flag appear labeling its function. The record button is on the far right hand side and you click that once. You will notice the "Oscilloscope" screen will begin to trace out the signal being recorded, along with the movement of recording position bar.

Let the sound record for about a minute and then click on the Stop button to the left of the Start button. Use your mouse pointer to move the recording position bar to the starting position and click on the Play button in the center of the controls.

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You should clearly hear what you just recorded being played through your computer's speakers or headphones. You should also see the "Oscilloscope" screen display the peaks and valleys of the sound you recorded. If you don't hear anything, check and adjust the volume control settings. If that doesn't work, check your cables and other connections until the source of the problem is found.

Now that you have your recording, you must save it as a computer file if you want to hear it at a later time. If you close the Sound Recorder program at this point the recording will be lost.

Click on the pull down menu item "Save" and then go to the item "Save As." You will see a new window for saving your recording as a file by giving it a unique name. Before you "Save," however, click on the button called "Change." This gives you access to a number of very important controls that allow you to select the digital sample rate and file format to save the recording in.

Take a close look at the various settings you can select from the pull down menus. You can set sample rates that range all the way from very "Low-Fidelity" (8000 kHz, 8-bit mono) all the way up to Hi-Fidelity (48,000 kHz, 16-bit stereo). Likewise you can employ a variety of different compression techniques, including MEPG Layer 3.

The most important thing that you can do at this time is to experiment with various settings, making note of the affect each has on your sound source. For instance, what affect does the setting have on the sound quality, or file size?

You will find that simply setting the values to the highest ones does not guarantee the best sound. Try different types of audio signals to record in different modes. For example, what affect does a setting have on a strong signal verses a weak one? How does a setting record a digital (e.g. Morse code or Teletype) signal? Do you need to have a high sample rate with such a signal?

Likewise note how lower sample rates impact upon minimizing the size of a file when it is saved. Try using various compression techniques and see exactly now much of a reduction each has on the final file size. Finally, go through the Help file provided with the software and review special techniques, such as controlling the playback speed, splicing and editing, and even special effects. Speed control is particularly important because it allows you to hear things you may have missed at normal speed, such as conversations, fast Morse code, or fading signals.

Again, make a record of each of your findings in your notebook. When you save a sound file, use a name that indicates the subject or the recording settings. Log them in your notebook for future reference.

The time you invest getting to know the audio software and what it can do will have a significant impact upon the success of future recording sessions. Remember that being in the middle of an important radio monitoring event is not the time to learn how to do something, particularly with computers.

Next Month

Having taken the time to ensure that your monitoring radio is properly connected up to your computer, and having mastered the basics of digital recording, next month it will be time to begin recording in earnest.

To help you, I'll introduce you to some advanced software products and recording techniques aimed at specific monitoring modes. One of the first things you'll discover is how inexpensive these software packages are. You will then find that if you have taken the time to master the Sound Recorder software outlined this month, these new software packages are very easy to operate, even with their advanced features.

That's really the main lesson here. If you take your time to plan and then build each part of your computer-assisted radio station based on your monitoring needs, you'll always be in control of the process.

By keeping that control, by understanding the theory behind what you do, by keeping a log and a checklist, and always having a clear goal in mind, you will generally be successful when working with radios and computers connected together.

Please e-mail or write to me with ideas, comments, and suggestions. The e-mail is carm_popcomm@hotmail.com. My mailing address is "Computer-Assisted Radio Monitoring," C/O Joe Cooper, PMB 121, 1623 Military Rd. Niagara Falls, NY 14304-1745.

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